

REVIEW AND SUMMARY OF STUDIES OF INSECTS ASSOCIATED WITH LEMNA MINOR*

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From 1931 to 1939 I have made observations of the animal population of *Lemna minor* found in the vicinity of Ithaca, New York. My interest has been centered upon insects that were more or less dependent upon Lemna, especially upon the Lemna fly, *Lemnaphila scotlandæ* Cress. This concentration led to the further study of parasites that emerged from the Lemna fly's puparia.

In making these surveys I have had little difficulty in obtaining duckweed, *Lemna minor*, for it abounds generally where there is quiet water, as in ditches, marshes, ponds, and small nooks along the banks of slowly flowing streams. Associated with *Lemna minor* are often large amounts of *Wolffia* and *Spirodela*, and infrequently small quantities of *Lemna trisulca*. The rainfall of a summer determines the available regions of quiet water on which Lemnaceæ can propagate. I have found tanks at the Cornell University fish hatchery (Plate XIV, Figure 4) and small ponds entirely covered by dense growths. The summer of 1939 was an unusually dry one for the vicinity of Ithaca and consequently many previous collecting spots were entirely bare. However, there was enough *Lemna minor* gathered to continue my records of animal life of this interesting association.

When I began these studies relatively few species of insects had been recorded as associated with duckweed. Among these there were two beetles entirely dependent upon this plant. A duckweed beetle, *Scirtes tibialis* Guer., was described in 1918 by W. C. Kraatz, who found it feeding entirely on *Lemna minor* in waters near Madison, Wisconsin. The other, a duckweed weevil, *Tanysphyrus lemnae* Fab., was reported by C. von Urban in the Entomologische Blätter (1922) as dependent upon duckweed for food. Lemna had been listed as the food plant of two aphids.

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In 1910 T. A. Williams gave duckweed as food of *Rhopalosiphum nymphæ* Linn. and in 1918 H. F. Wilson and R. A. Vickery recorded *Lemna minor* as a food plant of *Aphis sambuci* Linn.

Records of other uses of duckweed by insects include a paper in 1911 by Wm. T. M. Forbes in which he mentioned Lemna thalli as the material used for making the case of the aquatic caterpillar *Elophila*. In the same report he said of this case, "It is distinguished from those of *Nymphula* and *Hydrocampa* by the lack of a sharp lateral edge," implying that the cases of these aquatic caterpillars were also constructed of Lemna. He observed that the "leaves of the case do not seem to be eaten." Another paper which appeared in 1919 was H. B. Hungerford's, "The biology and ecology of aquatic and semi-aquatic Hemiptera," in which he reported the use of the under surface of Lemna thalli for the attachment of the eggs of the aquatic bug, *Trepobates pictus* H. S. These appear to have been the only definite references to the relations of insects with *Lemna minor* before my observations began in 1931.

Since that time I have published one general paper (1934) on "The Animals of the Lemna Association," in which I listed fifteen species of insects, and a second more specialized paper (1939) on "The Lemna Fly and Some of its Parasites." In 1938 F. X. Williams described and figured a similar Ephydrid, *Hydrellia williamsi* Cresson, as being found "on Lemna-covered water" in Hawaii and having "much the same habits as *Lemnaphila scotlandæ* Cress."

My own observations have been made on the following more permanent resident insects in the Lemna association: one Collembolan (*Sminthurus aquaticus* Bourlet), one Hemipteran (*Mesovelia bisignata* Uhl.), one Homopteran (*Rhopalosiphum nymphæ* Linn.), one Coleopteran (*Tanysphyrus lemnae* Fab.), one Lepidopteran (*Nymphula oblitalis* Wlk.), one Dipteran (*Lemnaphila scotlandæ* Cress.), and three Hymenopteran parasites (*Opius lemnaphilæ* Muesebeck, *Trichopria angustipennis* Muesebeck, *Trichopria paludis* Muesebeck).

The habits of these Lemna insects may be summarized as follows:

The diminutive spring-tail, *Sminthurus aquaticus* Bourlet,

jumps about on the floating mats of duckweed. Occasionally pairs will be seen to jump together, the yellow colored male being carried by the mauve colored female. The male has a clasping device on the second and third antennal segments composed of hooks and tubercles. These lock around the straighter antennæ of the female. The pair meet face to face, lock antennæ, and then, the female raises the male at an angle varying from a few degrees to as many as ninety. Sometimes a pair will remain together in this fashion for more than an hour. Duckweed serves this species as a source of food and also as a place for depositing the eggs. Many small holes are made in the thalli in the process of the prolific egg laying. Some idea of the damage to the plant can be gained from Plate XIII, Figure 3.

The bright green nymphs of the water strider, *Mesovelia bisignata* Uhl., are common on duckweed. The nymphs run quickly over the thalli and can easily dart out over the open water without breaking through the surface film. *Lemna minor* functions as a convenient plant in which the adults can lay their eggs. The elongate-oval eggs with curved necks are inserted singly between the epidermal layers of the Lemna thallus, their tips being exposed on the upper side, where they appear as shiny, membranous, ringed spots. Relatively little destruction of Lemna is caused by these carnivorous bugs.

The "pond-lily Aphid," *Rhopalosiphum nymphææ* Linn., is always very abundant in my collections. These aphids move about on the thalli and on the water, apparently unhindered by any moisture on their tarsi. They are very prolific. Viviparous females produce young almost daily during August. They feed upon the sap in Lemna thalli. One aphid may remain on a single plant for hours. No appreciable injury to the duckweed seems to result from the microscopic feeding punctures of this aphid and evidently the loss of sap is easily overcome by the natural metabolic processes in the plant.

The duckweed weevil, *Tanysphyrus lemnae* Fab., is commonly found in the egg, larva, and adult stages on floating Lemna. The pupa is less frequently seen. In the laboratory pupæ were obtained by placing grown larvæ in masses of sphagnum and leaving them there to pupate. This is the method I offered

in 1937 (Culture Methods, p. 480). Scattered clumps of Lemna thalli on moist earth also served as satisfactory cover under which wandering larvæ pupated. The mining larvæ devour the green interior of the thalli, leaving whitened plants, while the adults use their snouts to eat out spherical holes from the upper side of the Lemna. The destruction is very great, as may be seen in Plate XIII, Figure 2.

An aquatic case-making moth, *Nymphula (Hydrocampa) oblitalis* Wlk., is usually present in collections of duckweed. A dirty-whitish larva binds together overlapping thalli for a case. When deprived of one case, it proceeds to make a new one immediately. It nibbles off bits of duckweed for food. In the laboratory a single larva was placed with a quantity of Lemna in a Syracuse watch glass. This insect ate so many of the plants that only a few were left for its pupal case. Certainly *Lemna minor* is used for the growth of this moth.

The Lemna fly, *Lemnaphila scotlandæ* Cress., was discovered by me in 1933 and sent to Mr. E. T. Cresson for determination. It was found by him to be a new genus and species of the Ephyridae. It is very small (length 1.2 mm.); so small that it has the unique ability among all the Lemna insects of being able to pass through its whole life cycle on and within a single thallus. However, it is not strictly limited to a single plant. It may be found moving from one thallus to another, even crossing intervening stretches of open water. The larva is a miner, and on hatching it bores into the center of the thallus for food and shelter (Plate XIV, Figure 9). Here, also in the mine, the amber-colored puparium is found (Plate XIV, Figure 6). Normally there is only one pupa in a plant. However, recently, I found two pupæ crowded in a single thallus. The adult fly (Plate XIV, Figures 7, 8, 10-12) crawls out of the puparium between the epidermal layers of the plant and walks about on the duckweed. Very soon it begins to eat by gouging out portions of Lemna, leaving characteristic parallel streaks (Plate XIII, Figure 1). These peculiar markings on thalli prove an aid in detecting the presence of the Lemna fly in any quantity of duckweed. The feeding activities of this fly result in the almost complete destruction of the thalli. The female attaches her dainty melon-

shaped eggs to the margin of the thallus, as shown in Plate XIII, Figure 1 and Plate XIV, Figure 5.

Three specific parasites on the Lemna fly (Plate XVI) were likewise unknown. One has been determined as a new species of *Opius* (*O. lemnaphilæ* Muesebeck) and two as new species of *Trichopria* (*T. angustipennis* Muesebeck and *T. paludis* Muesebeck). All of these parasites emerge from fly puparia, leaving tell-tale holes in the empty shells, as shown in Plate XVI, Figures 20 and 21. Comparison of the numbers of these parasites in 1938 and 1939 revealed a marked reduction in the total number found in 1939 but a relatively constant ratio of the different species. In 1939 as in 1938 there were more individuals of *Trichopria* than of *Opius*. Of the *Trichopria* there were three times as many *T. angustipennis* as *T. paludis*. Males predominated.

In addition to these resident Lemna insects, all of which are of some importance in the economy of the plant, there are several transient visitants and chance associates commonly present. These are included below in a comprehensive list* of insects of the Lemna association.

COLLEMBOLA

Sminthurus aquaticus Bourlet

Podura aquatica—Larger than *S. aquaticus*, found rarely.

ORTHOPTERA

Undetermined nymphs of crickets—Observed running over a mat of duckweed. Captured individuals nibbled edges of the thalli.

EPHEMERIDA and ODONATA

Undetermined nymphs—Foragers among the roots of duckweed.

THYSANOPTERA

Limothrips cerealium Hal.—Probably from nearby grasses.

* The taxonomic sequence is that followed by Leonard in *A List of the Insects of New York*. Cornell Univ. Agr. Ex. Sta. Mem. 101, Aug. 1926.

HEMIPTERA

Mesovelia bisignata Uhl.

Trepobates pictus H. S.—Hungerford (1919) described and showed figures of eggs on the under surface of floating duckweed.

Gerris sp. Found on surface of Lemna mat.

<i>Notonecta</i> sp.	} Common aquatic bugs that move among the roots of Lemna.
<i>Plea striola</i>	
<i>Ranatra</i> sp.	
<i>Corixa</i> sp.	

HOMOPTERA

Aphis sambuci Linn. Not observed by me.

Rhopalosiphum nymphæ Linn. Very common.

COLEOPTERA

Tanysphyrus lemnae Fab.

Scirtes tibialis Guer. Not observed by me.

Haliphus sp. Larvæ and adults scurry among roots.

Laccophilus sp. Larvæ.

Hydroporus sp. Lays its eggs singly on the pendant Lemna roots.

Tropisternus lateralis Fab. Larvæ observed foraging among roots.

TRICHOPTERA

Limnophilus combinatus Walk. Used bits of Lemna in constructing its case.

LEPIDOPTERA

Nymphula oblitalis Wlk.

Elophila sp. Not observed by me.

DIPTERA

Lemnaphila scotlandæ Cress.

Hydrellia williamsi Cress. Not observed by me.

Corynoneura scutellata Winn. Larvæ, pupæ, adults.

Dasyhelea traveræ Thom. Larvæ, pupa.

Tetanocera sp.

Culex sp. Eggs, larvæ, pupæ.

- Anopheles* sp. " " "
Chironomus sp. Cases.
Odontomyia sp. Larvæ and pupæ.
Eristalis tenax—Larvæ.

HYMENOPTERA—All parasites.

- Opius lemnaphila* Muesebeck
Trichopria angustipennis Muesebeck } Parasites of Lemna fly
Trichopria paludis Muesebeck }
 Undetermined genus near *Aphanta* Foerster
Polynema sp. Parasite of Mesovelia eggs embedded in Lemna thalli.
Tiphodytes gerriphagus
Anaphoidea pullicrura

In a summary like this I cannot refrain from mentioning the unexpected manner in which new fields of investigation often present themselves. It was while I was searching for Hydroporus eggs in 1931 that these studies of the Lemna association began. I found the beetle eggs glued to the roots of duckweed. Upon looking through library sources I could discover no ecological study of the very common pond plant, *Lemna minor*. Thereupon, I undertook what has been a labor of love and what promises to be a life long inquiry into the wonders of this diminutive society.

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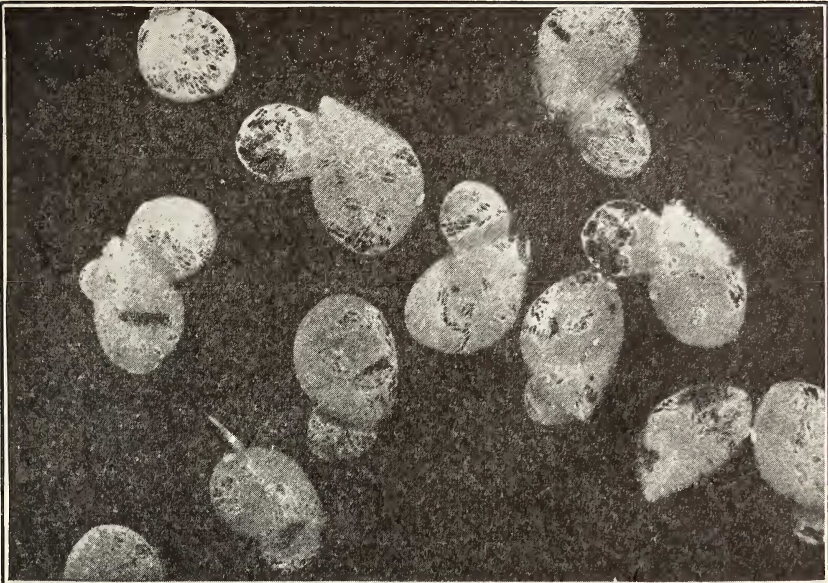
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PLATE XIII

Infested Lemna, showing injuries

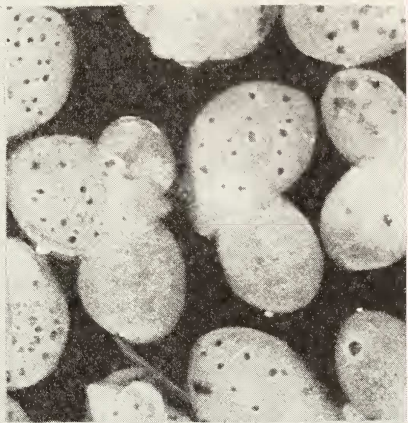
- Figure 1. The work of the adult Lemna fly, *Lemnaphila scotlandæ* Cress., which appears as parallel gougings. Nine of the thalli show eggs of this fly on their margins.
- Figure 2. The work of the duckweed weevil, *Tanysphyrus lemnae* Payk., showing the round feeding punctures made by the adult weevil and the irregular linear mines of the larva. One larva is visible through the transparent epidermis in a mine in the upper right.
- Figure 3. The work of the collembolan, *Sminthurus aquaticus* Bourlet. The round holes are the excavations in which the eggs were deposited singly.



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PLATE XIV

- Figure 4. A tank at the Fish Hatchery of Cornell University, Ithaca, N. Y., showing a thick floating mat of lemna, the joint habitat of the lemna fly, the case-bearing moth, the Lemna weevil, the pond-lily aphid, the water strider, and the Collembolan.
- Figure 5. The ribbed and sculptured egg of *Lemnaphila scotlandæ* Cress. The micropyle is seen on the right.
- Figure 6. Empty puparium showing the rupture through which the fly has emerged.
- Figure 7. Wing of the Lemna fly.
- Figure 8. Antenna of same.

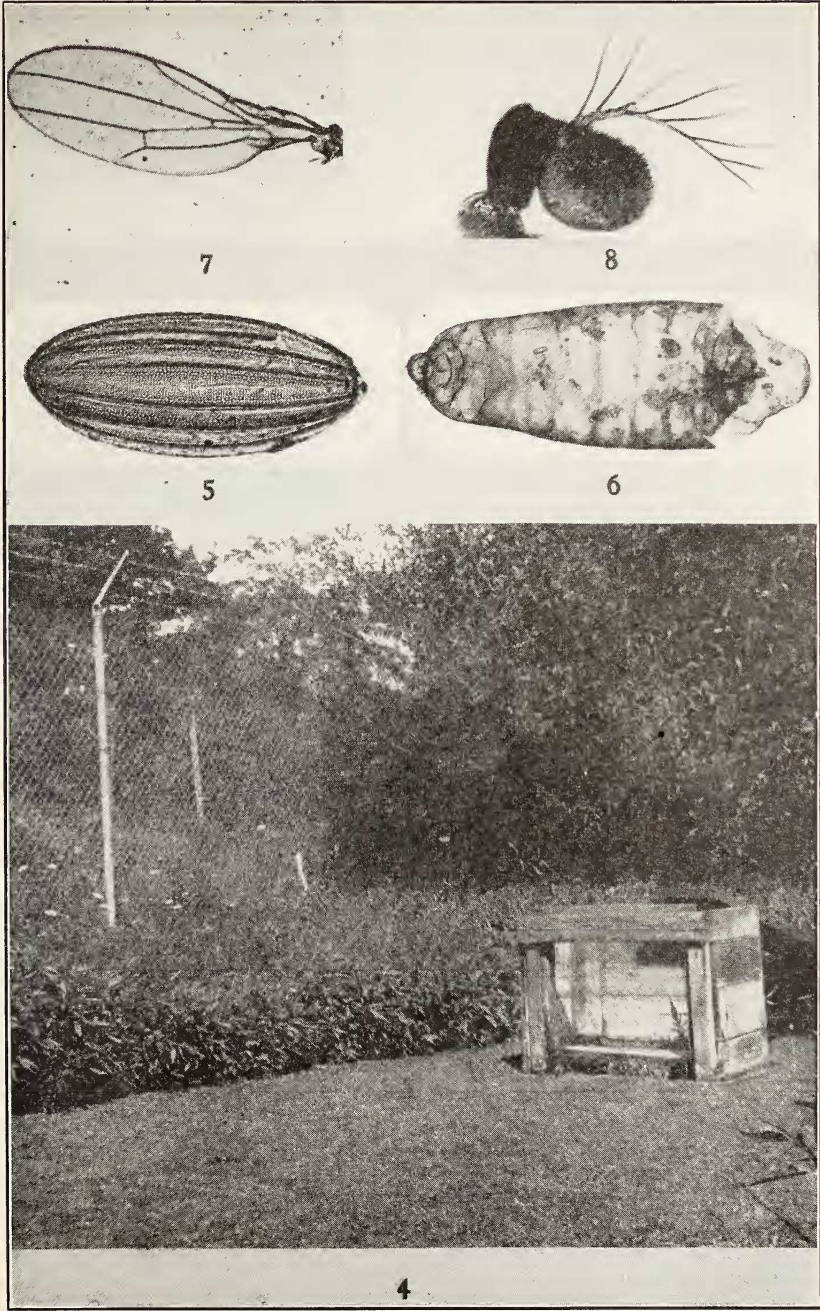
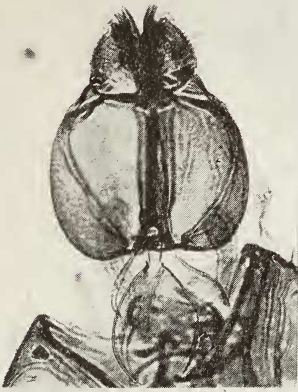
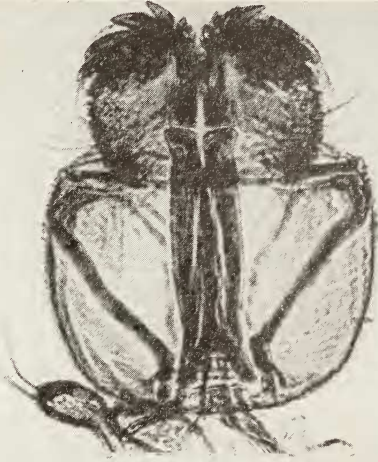


PLATE XV

- Figure 9. Tip of the mouth-hooks of the larva of *Lemnaphila scotlandæ* Cress., showing the serrated margin of the inner surface of one hook. The other hook of the pair, diverging in position, shows dimly, being out of focus. A palpus shows faintly in the lower left.
- Figure 10. Adult Lemna fly.
- Figure 11. Tip of proboscis of same with labella retracted.
- Figure 12. The same, more enlarged and with labella expanded, showing the hooks that gouge the parallel rows of holes in the Lemna thallus. A labial palpus appears at the left below.



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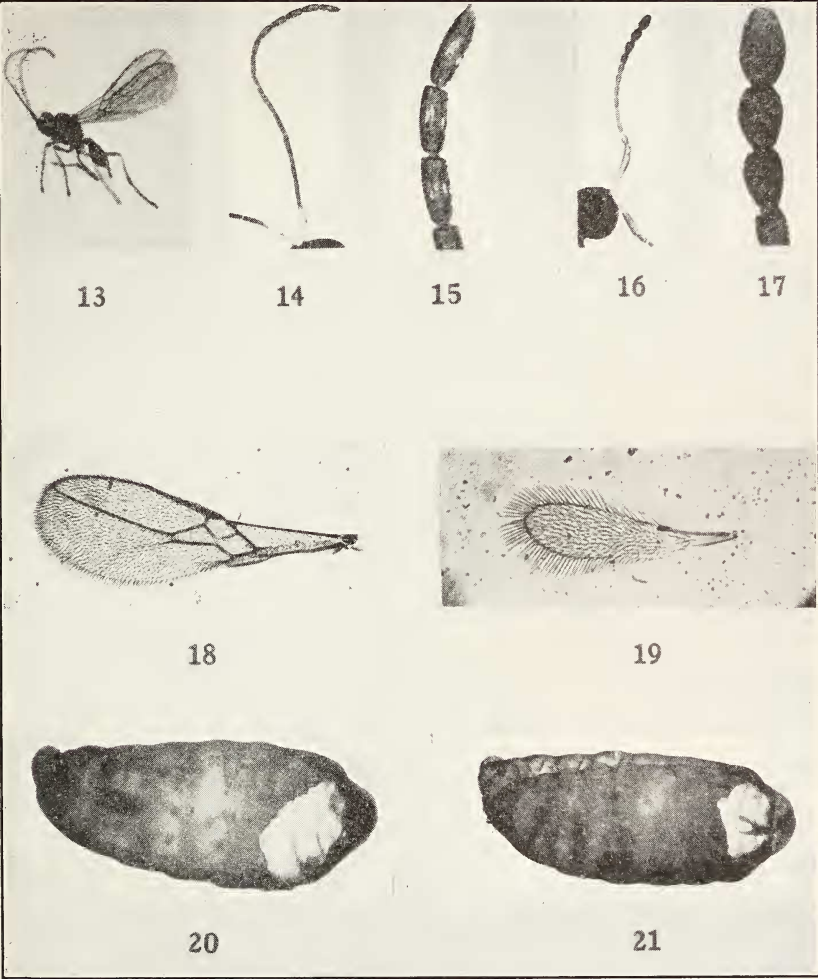


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PLATE XVI

Parasites of *Lemnaphila scotlandæ* Cress.

- Figure 13. *Opius lemnaphilæ* Muesebeck, adult female.
Figure 14. Antenna of same.
Figure 15. Terminal segments of same, showing sensillæ.
Figure 16. Antenna of *Trichopria angustipennis* Muesebeck.
Figure 17. Terminal segments of same, showing pit-like sensillæ.
Figure 18. Wing of *Opius lemnaphilæ* Muesebeck.
Figure 19. Wing of *Trichopria angustipennis* Muesebeck.
Figure 20. Empty puparium of *Lemnaphila scotlandæ* Cress., showing the large hole from which *Opius lemnaphilæ* Muesebeck has emerged.
Figure 21. Empty puparium of *Lemnaphila scotlandæ* Cress., from which *Trichopria angustipennis* Muesebeck has emerged.



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